Journal of the American College of Cardiology Vol. 60, No. 22, 2012

Published by Elsevier Inc.
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2012.09.006

EDITORIAL COMMENT

Coronary Magnetic Resonance Imaging

Coming of Age*

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The natural evolution of an imaging technology includes: 1) demonstration in phantoms and animal models; 2) testing in highly selected populations with defined disease; 3) single-center assessment in broader populations; 4) multicenter trials to define "real world" accuracy, and finally; and 5) assessment for prognosis/clinical management. It has been nearly 2 decades since the first reports of clinical coronary magnetic resonance imaging (MRI) in comparison with x-ray coronary angiography (1). Since then, there have been numerous technical advances in both hardware and software, with migration to whole-heart steady-state free precession without (2) and with (3) contrast as well as higher field coronary MRI (4). Multicenter trials in comparison with x-ray coronary angiography have also been performed both in the United States and Europe (5) and in Japan (6). Despite these advances, coronary MRI remains a niche application offered only at selected cardiac magnetic resonance (CMR) centers, often for patients with suspected anomalous or

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multivessel coronary artery disease (CAD). Its role in the diagnosis of CAD has not been widely embraced by the clinical cardiologic community. Though comparative studies suggest equivalent diagnostic yield for the detection of angiographic CAD (7,8) with superiority of coronary computed tomography angiography (CTA) for successful image acquisition and superiority of coronary MRI for accuracy in patients with high calcium scores (9), coronary CTA has more widely penetrated the clinical arena due to the technical ease of and much faster data acquisition and lower patient burden—despite CTA's need for iodinated contrast volumes similar to invasive x-ray angiography and exposure to ionizing radiation. It has been well recognized that conventional x-ray angiography is a suboptimal gold standard for the assessment of CAD. Indeed, fractional flow reserve is now considered a superior discriminator for the identification of lesions that warrant mechanical percutaneous intervention (10).

Even though diagnostic imaging tests are performed to identify those with CAD, there is also value in excluding disease. For those without disease on a noninvasive or invasive diagnostic test, clinicians want to know the "warranty period" of a "normal" test result. For stress testing, this is 2 years for nondiabetic patients (11), but only 1 year for patients with diabetes. For epicardial calcium on cardiac CT and for coronary CTA, the prognosis of "zero" calcium score or a normal coronary CTA is excellent (12). Similar data have been unknown for coronary MRI.

In this issue of the *Journal*, Yoon et al. (13) report for the first time on the moderate-term prognostic value of coronary MRI. A total of 207 patients with suspected CAD underwent noncontrast, free-breathing whole-heart steady-state free precession coronary MRI in 2007 and 2008 are followed for a median of 25 months. The most common indication for coronary MRI was chest pain. Forty-one percent had significant CAD on coronary MRI, of whom there were 10 cardiac events, including 5 severe events (cardiac death: n = 1, unstable angina: n = 4), for an annualized event rate of 3.9%. Of the 123 (60%) without significant coronary disease on coronary MRI, none underwent revascularization and there were no cardiac events (annualized event rate: 0%). There was 1 noncardiac death due to malignancy. The presence of a stenosis on coronary MRI was the most significant predictor of all cardiac events.

Although a small study from experienced CMR investigators, these data do provide the first insight regarding the warranty period of a normal coronary MRI and add to the growing prognostic data regarding multiparameter CMR, including late gadolinium enhancement for ischemic and nonischemic cardiomyopathies (14–16) and volumetric left ventricular ejection fraction (17). Though Yoon et al. reported solely on coronary MRI, comprehensive CMR examinations provide information far beyond coronary artery lumen assessment. At our institution, coronary CMR is most commonly performed in combination with assessment of biventricular volumes and regional/global systolic function and late gadolinium enhancement. The recent CE-MARC (Clinical Evaluation of Magnetic Resonance Imaging in Coronary Heart Disease) study (18) demonstrated the superior accuracy of multiparameter CMR versus pharmacologic radionuclide single-photon emission CT imaging for 759 patients with suspected CAD. Prognosis data from this prospective multiparameter CMR study are eagerly awaited and offer the opportunity to examine prognostic data of individual components of the CMR examination.

*Editorials published in the *Journal of the American College of Cardiology* reflect the views of the authors and do not necessarily represent the views of *JACC* or the American College of Cardiology.

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Finally, we need some reality testing. CMR is moving into the mainstream of clinical cardiology, but the study of Yoon et al. (13) does not provide a license to expand coronary CMR testing for purposes of prognosis in patients concerned about their risk of CAD or even those with multiple CAD risk factors. These patients were not studied. As with screening exercise tests in high risk asymptomatic populations, applications of testing in what may seem "logical" populations does not always result in improved prognosis (19). Even though coronary CMR testing is noninvasive and has minimal patient risk, there are tremendous potential costs to our healthcare system with the introduction of novel high-technology tests. We can no longer afford to simply add these new imaging technologies to our existing evaluation paradigms. Will the prognostic value of a normal coronary MRI (or comprehensive CMR study or coronary CTA or stress) myocardial perfusion be superior to less intense technologies (e.g., stable symptoms and able to exercise 10 metabolic equivalents of oxygen consumption without symptoms or ischemia on a nonimaging exercise stress test)? We need to rigorously assess new technologies using decision analysis methods and identify clinical pathways in which these new technologies will displace rather than simply add to existing management strategies. Yoon et al. have provided important information with regard to the prognosis of a normal coronary MRI in patients with suspected CAD. Now we need to confirm their findings in larger multicenter studies and, most importantly, learn how to responsibly integrate their findings into the management of patients with suspected CAD in a cost-efficient manner. In so doing, coronary MRI will emerge from its adolescence to define its role in clinical cardiology.

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Key Words: coronary artery disease ■ magnetic resonance angiography ■ morbidity ■ prognosis.